Gwyn Winfield looks at the role of GC and MS in the interrogation of clandestine drug labs

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The previous article looked at the role of 'triage' detectors in detecting trace elements of narcotics, and technologies such as SORS Raman, hyperspectral and high throughput vertical slit (HTVS). Depending on who you talk to, these either can or can't do trace identification. This is not so much down to the quality of the detector, but the definition of trace. For some individuals trace could be something you might see, a few grains of powder on a dashboard, for example… for others it might be a small amount of chemical hiding in one of those grains on the dash.

In some areas of chemical detection, such as explosives or chemical warfare agents, the difference between the two definitions is quite small, you want your agent to be as pure as possible to maximise effect. For narcotics the opposite is true, you want your drug to have the minimum effective dose and be packed with things that might not kill the user immediately. Once fentanyl and its analogues gets involved then that percentage drops down to the 'say what?!' level.

Fentanyl is so potent that what would be an effective dose for a long term heroin addict is a lethal dose for someone not used to the drug. Added to that there is the problem that drug dealers use it as a booster for conventional drugs. If heroin costs quarters in the dollar then fentanyl is cents, this allows dealers to cut 'pure' heroin with fentanyl, to maximise profitability without the user thinking they have been pharmacologically short changed. This means that an individual trying to look inside a sample might see the opioid peak, and reach the conclusion that it was (relatively) benign heroin… whereas it actually has minute levels of the far more toxic carfentanyl. As discussed in the last issue triage detectors are getting much better at doing this… but it does depend on how much active compound is in there.

If you really need 100% confidence in what you are looking at you must be able to start introducing samples to gas chromatography (GC) /mass spectrometry (MS). This is often termed the 'gold standard', but, hackneyed expressions aside, it does provide a very

GC and MS allows identifiers to see past the initial opium spectra ©DoD

high certainty about what is in the atmosphere. The last word is perhaps the most important. Many CBRN old hands will have watched a dual wheeled sampling system on the back of a Fuchs/Fox bringing a sample up to a heating element so it can provide vapour to Bruker's on-board GCMS. Traditionally the devices have been used to provide an atmospheric analysis, yet it is not impossible to use liquid or solid samples, although it does require a certain amount of sample preparation and the necessary training, in bulky personal protection equipment, (PPE) to do it.

The past 15 years has seen GCMS creeping closer and closer to the hot zone. Firstly in recce vehicles and mobile labs, but much more in the shape of man-portable versions, first with Inficon's Hapsite (GCMS), and then with more recent entrants from Torion (GCMS), 908 Devices (MS), First Detect (MS), Seer Technology (GC) and Flir Detection (GCMS). Previously the market for a lot of these devices was pretty slow, with a fairly stable chemical market it was a difficult procurement decision for a lot of forces to make. This exploded in the last couple of years with the fentanyl epidemic. While they remain a rare bird, compared to common or garden Raman, there seems little doubt that while the epidemic rages they will become more of a feature.

Ironically it is the more recent adopters of the technology that have set up camp in the narcotics identification market. "[Narcotics/fentanyl] has changed the industry as a whole in the last five years," said Dr Christopher Brown, chief technology officer of 908 Devices. "Drugs, which had their own pool of users and needs, are now merged into the larger community. Five to ten years ago general fire hazmat didn't have a demand for the identification of drug substances, but the hazards associated with high potency pharmaceuticals like fentanyl mean it is now a hazmat problem. Cheap and easy wet chemistry always has a place, but the major problem, especially with the higher potency synthetics, is that you need a finer degree of information than the kits can provide. Teams that would have got by in the past with a NIK kit [such as https://www.safariland.com/products/forensics/field-drug-tests/nik-drug-tests-and-kits/, Ed.] find it doesn't provide them with enough breadth and sensitivity for the basic job they had to do five years ago. Even though these are perceived as cheap and easy they are not that cheap when you look at the amount of testing these teams need to do. People want instruments with higher selectivity and sensitivity that offers better detection and protection," he continued.

The latest entrant to field portable GCMS is the Griffin G510 from Flir Detection. Dr Ross Harper, Business Development Manager for the sector, agreed that the market had suddenly opened up, but this means that some education is needed within the customer base. "Narcotics is one of the main avenues we are chasing. The original markets for a field portable self-contained GCMS were hazmat, other first responders and the Department of Defense (DoD) downrange market. As the opioid crisis advanced, then more narcotics, including synthetic cannabinoids, that are not in an IMS or Raman library appeared. Then you get into mixes with highly potent fentanyl compounds where the only way to correctly identify them is to do some form of separation upfront followed by a spectral analysis against a broader library.

"The G510 is not your traditional front line narc detector. If you talk to law enforcement who rely on a NIK kit or a Raman detector they are used to getting results in 25 seconds, wiping something off and going again. It's important to help them into the right mindset when considering an instrument you need to power up, run a blank to make sure it is clean, and then perform a 10 minute analysis. They have to get used to the idea that you are looking at 20 minutes of analytical time and they'll say "20 minutes, I am used to 20 seconds!" What we are doing though is not applicable to Raman or colorimetric, it is applicable to taking a bag of some substance, rushing it to the crime lab and then waiting a month or two to get the results," Dr Harper continued.

Inficon, with a product more established in the market, has yet to produce something optimised for the narcotics field, but is starting to catch up. "The narcotics piece is on the radar for us, we have been doing quite a lot of R&D and making progress and we think that for future products and development in the security and environmental markets narcotics will be a additional growth opportunity. We have done other research that is narcotics based, but nothing we are publicising at this stage," said Mr Tim Crofton, product centre manager GCMS at Inficon.

In the life of every sample there is a very good chance that it will be introduced to GCMS. The question every responder has to answer is: when is it? As Dr Harper noted, the answer might be at a crime lab, where it will be subjected to a highly capable GCMS. Some, however, might decide that they want something closer to the scene and will bring in a mobile lab. That might have a slightly more ruggedised GCMS, and some might even decide that they want the capability even closer – up to and including the crime scene itself. It is in the last two options that all the devices mentioned above play in. They can be in a mobile lab, which might be an articulated trailer or something more rudimentary in a van or SUV. The GCMS from Inficon and Flir Detection are certainly heavier than 908 or First Detect's mass spectrometers, but they can still be carried by one person into austere sites and operated. What this boils down to is how important is time in the identification cycle?

Previously, the answer was 'very' when dealing with chemical weapons, or even toxic industrial chemicals (TICs). Every decision was both life-saving and politically important. With the narcotics piece the answer is more nuanced and individual.

Dr Harper felt that some forces will always bag a sample and send it off to the lab, but for those wanting confirmation that their PPE would give them the required protection, or a higher throughput, or real-time intelligence -

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deployment as close as possible to the scene would be the right path. "Being realistic I don't see it in the back of every police car or 4x4. We designed the G510 to be used by people with a technical understanding of how to prepare a sample to avoid overloading the sensor, what you can and can't inject etc. As such we target it towards the mobile lab or the supervisor level, where you have an officer that has been doing this longer with a couple of sergeants that are used to a technical approach. Would we only limit it to mobile labs? No, but equally it isn't suitable for every cop.

"[In terms of lab based systems] if you compared the G510 to an Agilent or traditional lab-based system, then it would be the same GC column chemistry, quadrupole libraries, 70 electron volt ionisation, and NIST libraries - so the spectra would be very comparable. If you had a portable Agilent system then you wouldn't see much benefit in running a G510. We do have the benefit of the PSI probe accessories, meaning we can do direct sampling of white powder without solvent work or sample prep. Where we benefit compared to mobile labs is that the G510 doesn't need external power, gas, a computer – what you see is what you get. It integrates nicely into mobile labs, but it could be in an SUV and within 20 minutes it would be good to go. The advantage of being self-contained is that if you have the lab at the scene you can bring the instrument into the scene rather than taking samples out to the lab. The process is streamlined a little bit more, not to mention the vapour capability and you are getting into clan labs and you can move away from white powder into air sampling and whether the atmosphere in the lab is even breathable."

Since the chances of having aerosolised fentanyl in the atmosphere are slim, the operator will have to take a sample. As mentioned in the previous issue it is seen as a big plus in the Raman camp, that the various systems can interrogate a sample through a glass or thin packaging. For MS or GCMS a sample will have to be taken that will require some kind of interaction with the target. This could be as little as a swab,

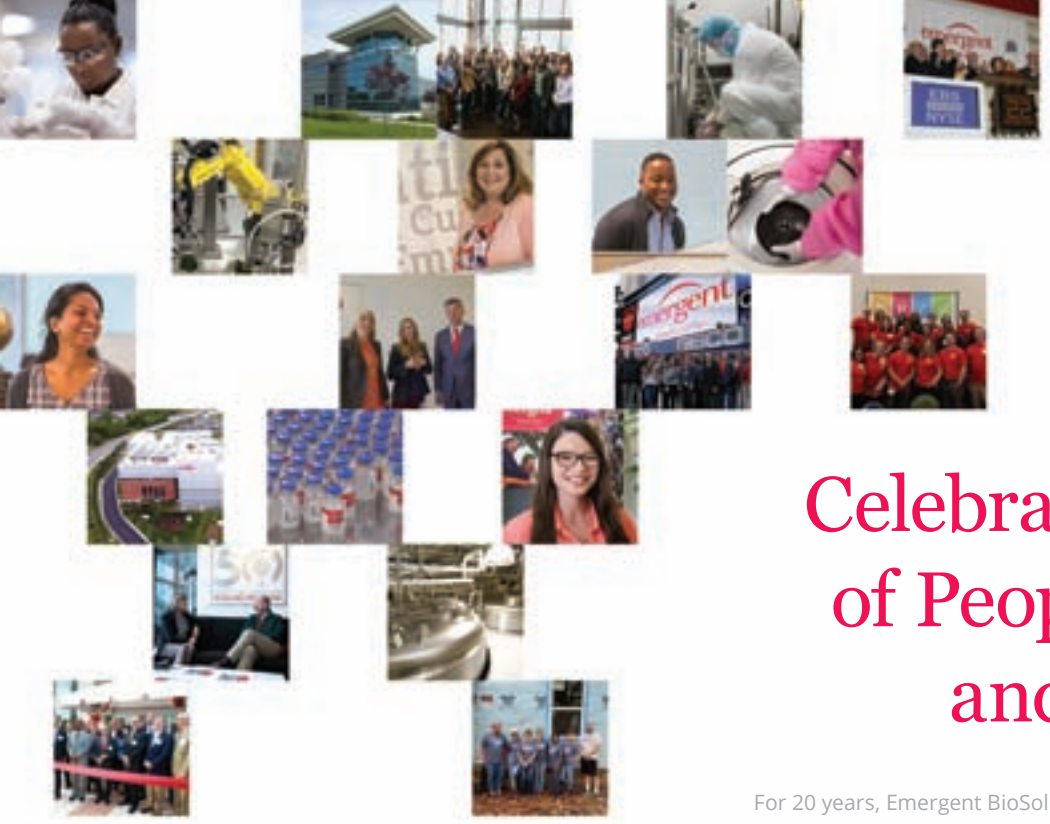
GC and MS companies are rapidly identifying a commercial opportunity in the narcotics identification market ©DoD

but equally it could mean that the drug needs to be dissolved in solution. All of this could potentially put the operator at risk from booby traps.

Dr Brown understood the attraction of Raman, having had a long history with the technology through his Ahura background, but felt that the interaction with the target was minimal. "It may be minute. Our approach is reliant on swabbing a surface if not the direct material itself. In many field cases swabbing the outside of a box or packaging is enough to get a residual containing nanograms of material. Some hazmat teams consider it a non-contact threat, as they don't have to break open a big baggie of powder to get the information. Raman's trick is to see through transparent packaging, and SORS will do opaque if it is thin, but it won't help with layers of cardboard and foil packaging."

Flir Detection also works from swabs, but points out that with such minute traces of target analyte it might actually be missing on the swab. As such it is easier to be safe and take a larger direct sample and interrogate that. "When it comes to a tablet the best way is to get it into solution, to homogenise it. Traditionally we talk about doing mystery powder analysis with the PSI probe, getting a crystal and dropping it in. When you start looking at really low quantities of potent synthetic narcotics, there is a high likelihood of missing them if the sample is not homogeneous. Often it could be a fraction of the tablet as the people that make these rarely make them homogeneous to begin with: some tablets have nothing and some have a lot. We have reverted to wet chemistry with condensed phase injection using our split list injector. We have one sheriff's office that takes a whole tablet, grinds it up, squirts in some solvent and then shakes it up. You end up with a bright blue solution, all the inorganics settle out and traditionally you would work with the mindset that you need to dilute it down because it is far too concentrated for GC, but we are looking for trace sub one percent constituents, so you need to run the concentrated sample to see it. You inject in, put a high split ration on the method, and sure you have this big ugly acetaminophen peak up front then you get the fentanyl peak after."

As mentioned earlier the use of GCMS in this field is relatively new, and the scientific papers are struggling to keep up with practical experience. If you want to know which surfaces work well with swabbing for target analytes the people to talk to are not the scientists but hazmat techs. Potentially it's a



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problem for the manufacturer to claim with anything other than anecdotal evidence what works well in terms of swab efficacy. Dr Brown agreed that the shortage of scientific papers, or at least those that worked with real-life substrates rather than glass, was lacking, but that through their training classes they had managed to share best practice.

"If anyone publishes a report," said Dr Brown, "it is a lab group wanting to know how much they put down and have a controlled and reproducible scenario. Hazmat folks don't have that luxury. Word of mouth and experience in practical swabbing materials is much superior but it doesn't appear in published studies. A lot of teams are used to sampling for some degree, and these teams have little drop trays to create a clean area in which they can work. We do them a disservice to say that they can't sample in environments like car footwells, a lobby or a car park. We run workshops for end users where they share best practices for sampling and cleanliness and experiences they have had. We can put ourselves through all kinds of contortions to try and create scenarios, but there is nothing like the real thing. Through our reach back service we provide a line where a team can call us in real time, if they want guidance or to send us data for evaluation. We have incidents daily with attending chemists on the line, and we say 'tell me what you have got, tell me how you sampled?' This gets captured in real time and disseminated on the support channels. Many of the things we do in training have come from field interactions with users, or observing them in sampling exercises."

As discussed in the last issue the challenge for Raman, and other technology, is staying on top of library development – mixes and new substances can make identification difficult. That is much less of a problem for GCMS, which can see the entire signature and through separation and comparison to NIST, Wylie or the Scientific Working Group for Drug and Explosive Analysis can identify any experimental compound. While this might not be enough to start doing the kind of chemical forensics beloved of the TV CSI series, it does allow accurate identification of everything, no matter how small, in that tablet or wrap. Dr Harper explained: "They are now starting to cut fentanyl into heroin samples. Given the difference between traditional opioids and fentanyl analogues, combined with the possibility of sub one percent fentanyl contamination, then you won't see it with Raman or some kind of bulk analysis because it is such a minor constituent, which is one of the benefits of having up front separation.

"We see a lot of ground up Tylenol, a small amount of fentanyl is inserted and it is re-pressed to the original size and shape. It looks like a Tylenol and under a Raman analysis it looks like Tylenol but it contains a significant hit of fentanyl. That is where being able to do separation up front helps and we have customers that have taken that to heart. We worked with one office of emergency management, who brought a sample that came from a confidential informant. They knew it should contain fentanyl, but couldn't prove it with their infrared or anything else they had in house, we ran it and it came back heavy in oxycodone, caffeine and then there was this fentanyl peak in the background. The combination of oxy and caffeine meant that they knew who it came from. That is where the cutting agent starts to become of investigative benefit."

Nobody suggests that it is an either or, triage or identifier, equation. Organisations will still need to use their current Raman, or equivalent, to get 80% of the way there, the MS package will be used to provide incontrovertible evidence of what is in the sample. "Everyone wants the easy button," said Inficon's Tim Crofton. "Something small and portable so when I press the button on my tricorder it tells me what it is! When dealing with toxic compounds we want to make sure we have reliability as we are talking about life and death. It is always possible with some of the more triage level products that there could be lower levels of concentration that could be missed. We are capable of testing to that level and before I allow first responders or K9 units in, I want to make sure that I have the right detection level. Full GCMS enables me to target something in a complex background, and we have some cases where there are different compounds and mixes, making it very difficult to identify what's there in what concentration. Being able to identify the different precursors, degradients and impurities is important."

All three companies have big plans for focusing their products on this growth market. First out of the blocks is 908 Devices with its Drug Hunter upgrade, that allows identification of over 2,000 fentanyl analogues. While this does not put them on a par with a full GCMS system it does allow for dealing with mixes better by focusing on certain spectra. Dr Brown explained, "Fentanyl typically exists as a base of one of five to seven salt forms, and each form has a different vibrational spectrum, so you need a library reference for each of them for Raman and FTIR, which is a pain. MS doesn't care about salt forms, they liberate when we heat up the swab and then when we look at the fragmentation from the MS different isomeric forms don't matter as you are breaking the molecule down. As long as it has the constituent groups associated with that drug it will still alarm despite looking different on a vibrational system.

"Drug Hunter mode[1] is a style of fragmentation that allows us to pick apart a molecule. If we know what class it belongs to then it is surgical dissection of a class of molecule that allows us to get information leading to classification despite different constituent groups that might be present. This will be huge and provide a tremendous amount of coverage, and is unparalleled in the field. It can also apply to other classes of compounds, such as synthetic cannabinoids, which pose the same problem even if they don't have the same press as fentanyl. We will continue to broaden the base library into other pharmaceuticals that regularly appear," he continued.

The Griffin G510 has only recently been released onto the market, so little is

[1] www.cbrneworld.com/news/908_devices_mx908_unlocks_detection_capabilities_for_more_than_2000_fentany


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expected in the way of short term improvements, though Dr Harper suggested that there would be software improvements, further developments in sampling tools for solids, liquid and vapour and maybe a more targeted narcotics version in the future. "The G510 is a huge leap forward over the 400 series in terms of size, weight, and analytical capability. We moved from the cylindrical ion trap to a quadrupole core, which came with the loss of MS/MS capability, but allowed industry standardisation with NIST libraries. Much as we had a family of Griffin G400s, with different applications and abilities, we are looking to distil the G510 family and accessories. So while the G510 can be taken down range not everyone wants to lug a 36lb (16.6kg) instrument down range and risk it all on being deconned later, so we might look at smaller accessories and increased portability. We are currently evaluating the Wylie drug library to see if that works and importing the SWGDRUG library, in addition to the ability for users to create their own libraries."

Inficon has worked on fentanyl in the past, as it has been considered a fourth generation warfare agent, but largely for defence customers, not first responders. This is likely to change at some point in the future, as Rebecca Robertson, Department of Defense account manager confirmed. "Our work with fentanyl and some of these other types of chemicals is still under development and not commercially availableyet. We are working towards that and having done successful testing with those compounds we see great promise based on those internal tests."

Tim Crofton agreed: "It is all about pushing the edge of the envelope to get down to the lowest detection levels based on the toxicity of what we are seeing in the workplace. That is our focus, to make sure that our technology can reach these low levels and go beyond what we have done in previous developments."

All three companies were adamant that GC and MS will maintain its analytical advantage over the other forms of the 'Holy Trinity' (mass spectrometry, vibrational spectroscopy like Raman or FTIR, and nuclear magnetic resonance spectroscopy), in the clandestine lab at least. Improvements in Raman will close the gap between them and MS, and 908 Devices' improvements in MS will also see it erode the advantage of GCMS… but fundamentally it will come down to how much information do you need, by when? There is a training burden to these products that is difficult to maintain in cash strapped times. I have been in more than one firehouse where their Hapsite has been put under a bench as the guy that knew how to use it has moved on, and they can't afford to replace them yet. For many hazmat departments the fentanyl epidemic has become yet another job they are poorly funded to do, and while they would dearly love to have improved analytical capability they lack the funds to purchase, maintain and staff it.

Teams that can tap into enough grant funding will undoubtedly now be trying to find the right balance between Raman, MS and GCMS. Buying all three gives a balanced capability, from 'fast' at one end to 'certain' at the other, and the same sampling team that does the mass spec can also run the GCMSas, so economies can be gained from having one of each. It is expensive though, especially when 'good coppering/hazmat' will likely lead to the same gut instinct that a $80-120k piece of equipment could confirm. The field advantage, as Dr Harper pointed out, will come when batches can be linked to criminals, and that in near real time. To be able to provide actionable intelligence in a timely manner, rather than just confirmatory analysis is what will make these budget decisions make sense.

While fentanyl claims the most headlines other novel psychoactive substances, like cannabinoids, pose a similar threat ©DoD